Thunderstorm Nowcast and Forecast for Aviation Safety and Efficiency

Validation by IAGOS flights

by

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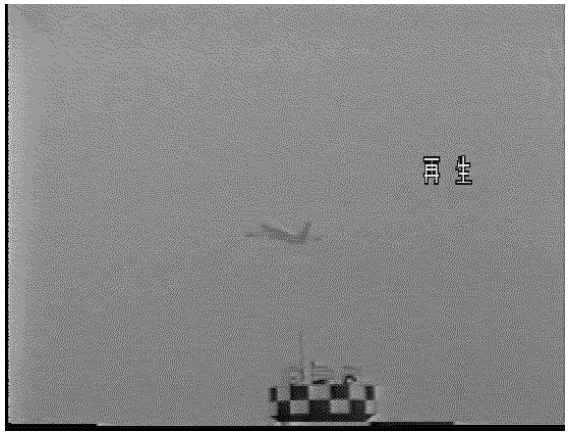
Joint Annual Meeting of IAGOS and IGAS,
CIC Météo-France, Toulouse,
November 18, 2015

DLR

Innovative weather forecast system for aviation – why?

Example thunderstorms

icing



lightning

hail

- Adverse weather is responsible for 40-50% of all delays in Europe
- Thunderstorm activity is the reason for up to 90 % of all delays in the airspace over the USA during the summer months.
- Thunderstorms are the most dangerous weather phenomenon for aviation (survey with pilots)

Thunderstrom information for aviation is still rudimentary these days!

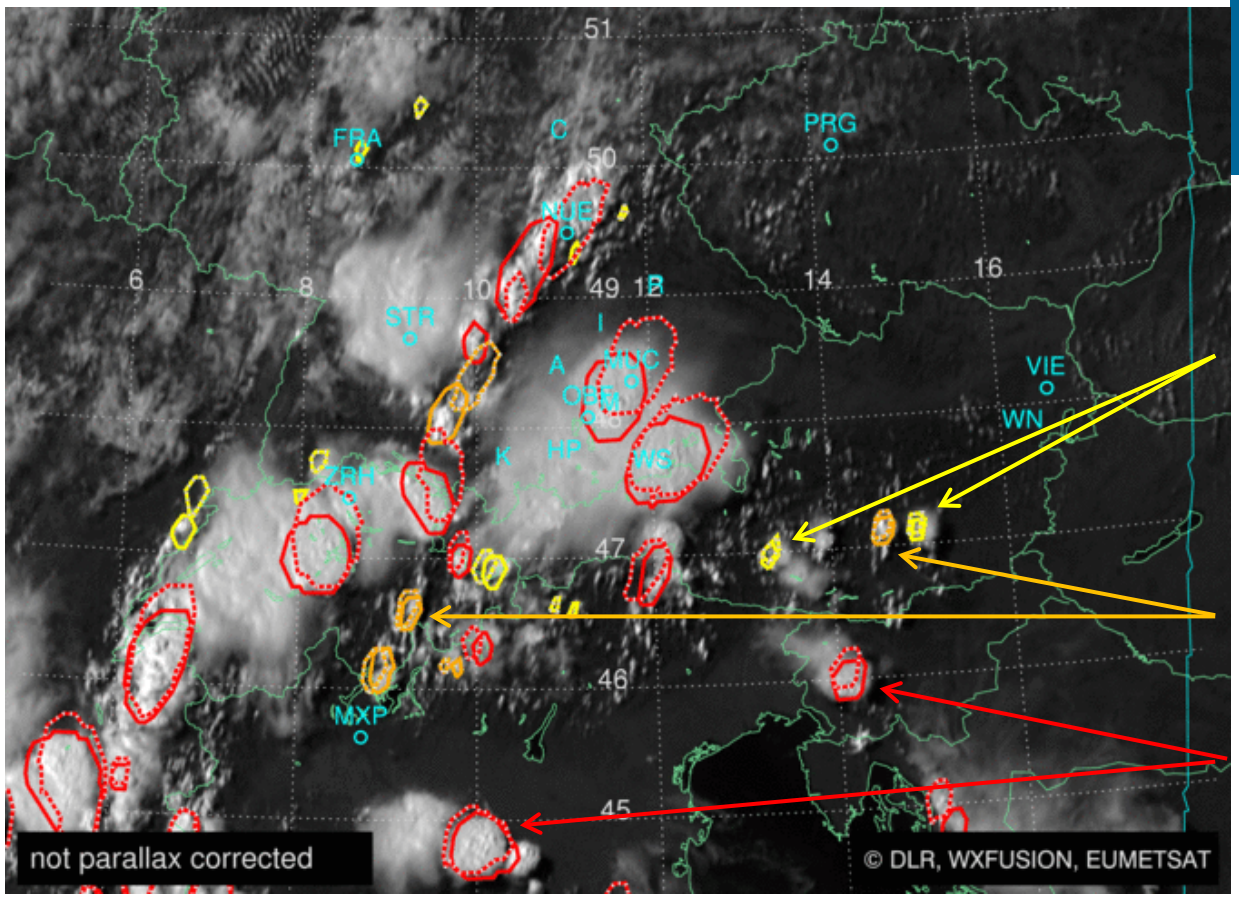
Goal: Help to increase safety and efficiency for air traffic during adverse weather situations

DLR

Cb-TRAM - Cumulonimbus TRacking And Monitoring

satellite data analysis
→en-route

Used MSG (rapidscan) data:	
WV 6.2	IR 10.8
IR 12.0	HRV



potential development -yellow

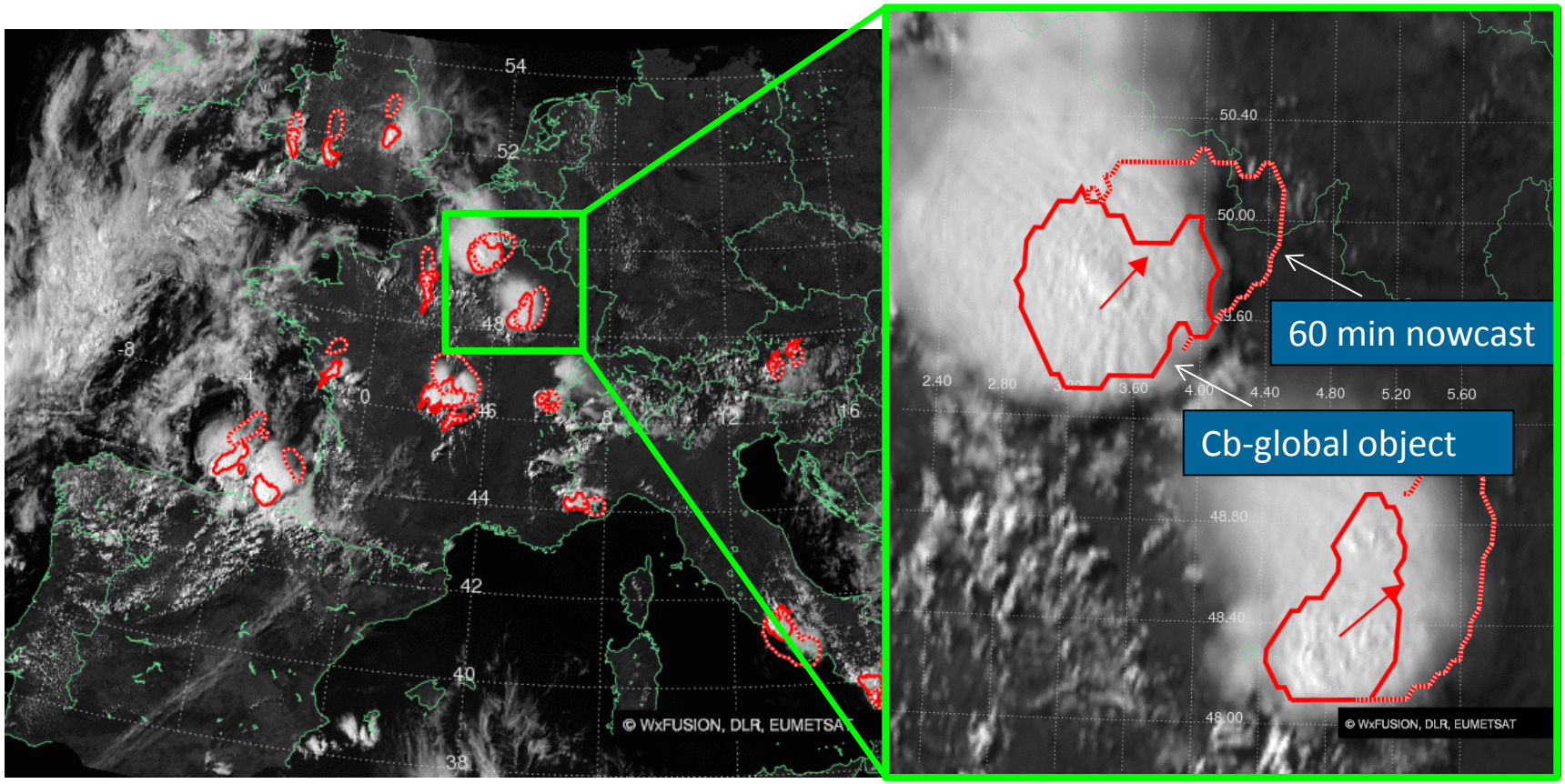
rapid development - orange

mature thunderstorm - red

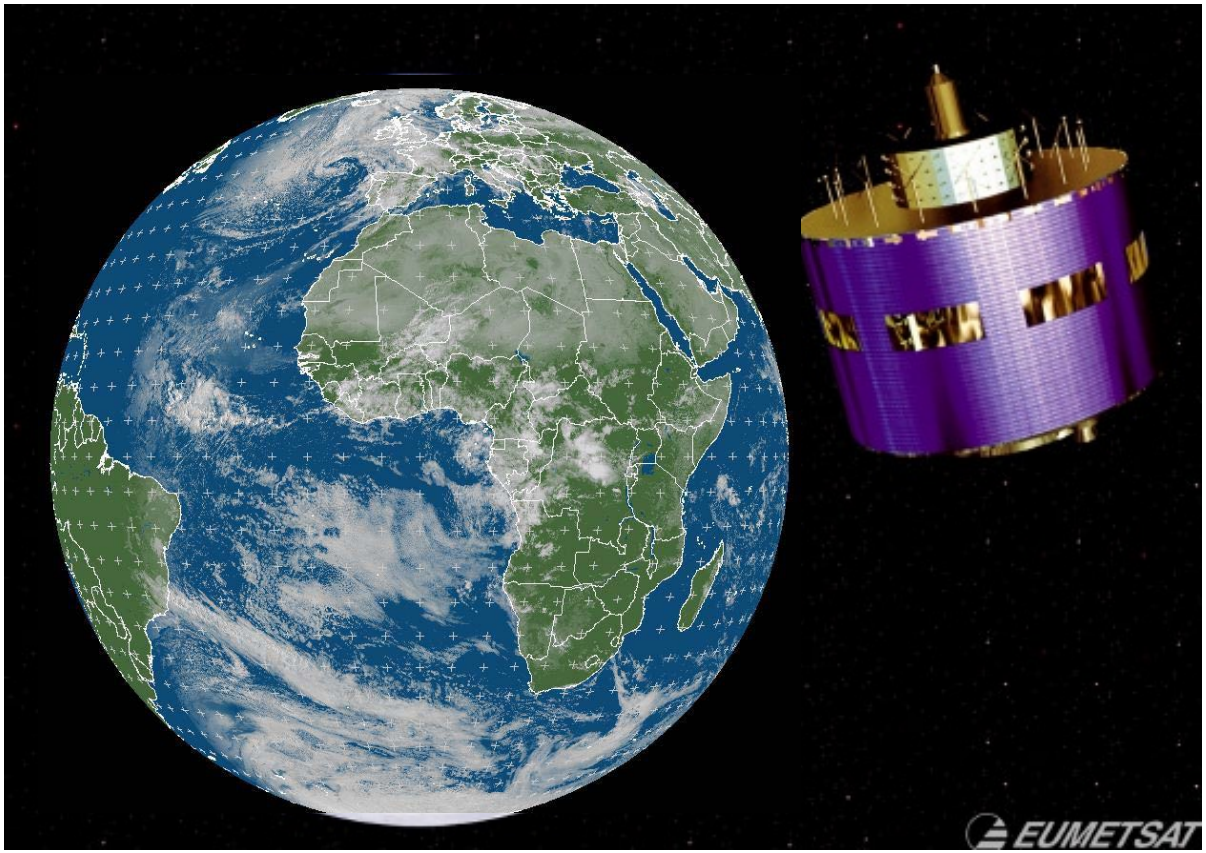
Cb-TRAM - Cumulonimbus TRacking And Monitoring

satellite data analysis

→en-route



Cb-TRAM - Application area Meteosat



Resolution 15 (5) minutes
1 / 4 km (VIS/IR)

DLR

first successful data link tests
cooperation DLR - DLH

Foto: Capt. Andreas Borengässer (Lufthansa Cityline)

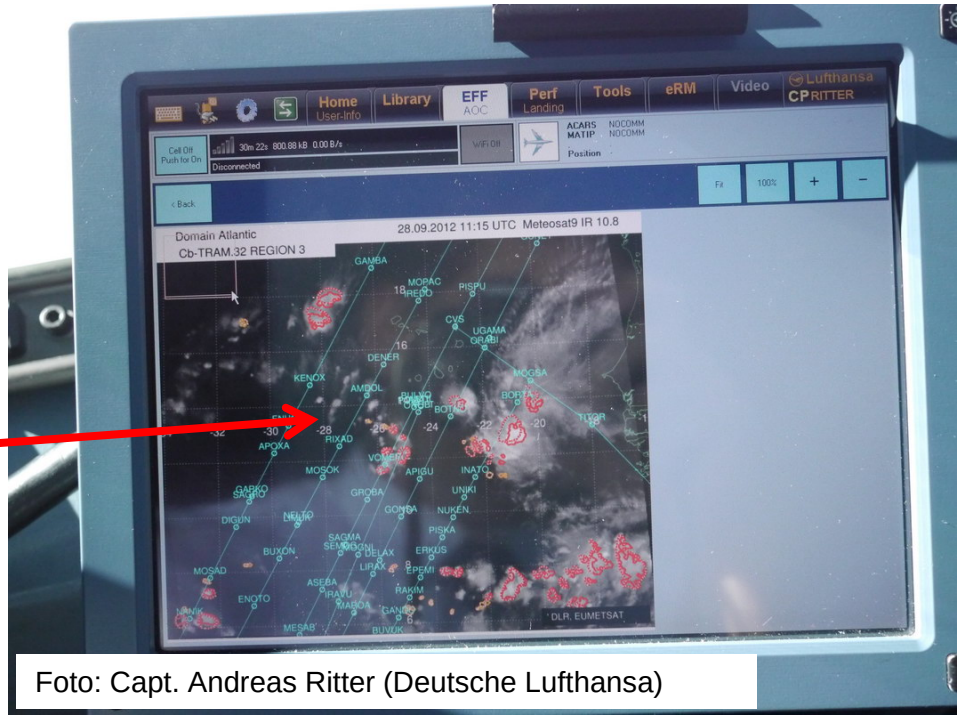


Foto: Capt. Andreas Ritter (Deutsche Lufthansa)

Lufthansa GADCom project (Ground Air Data Link Communication):

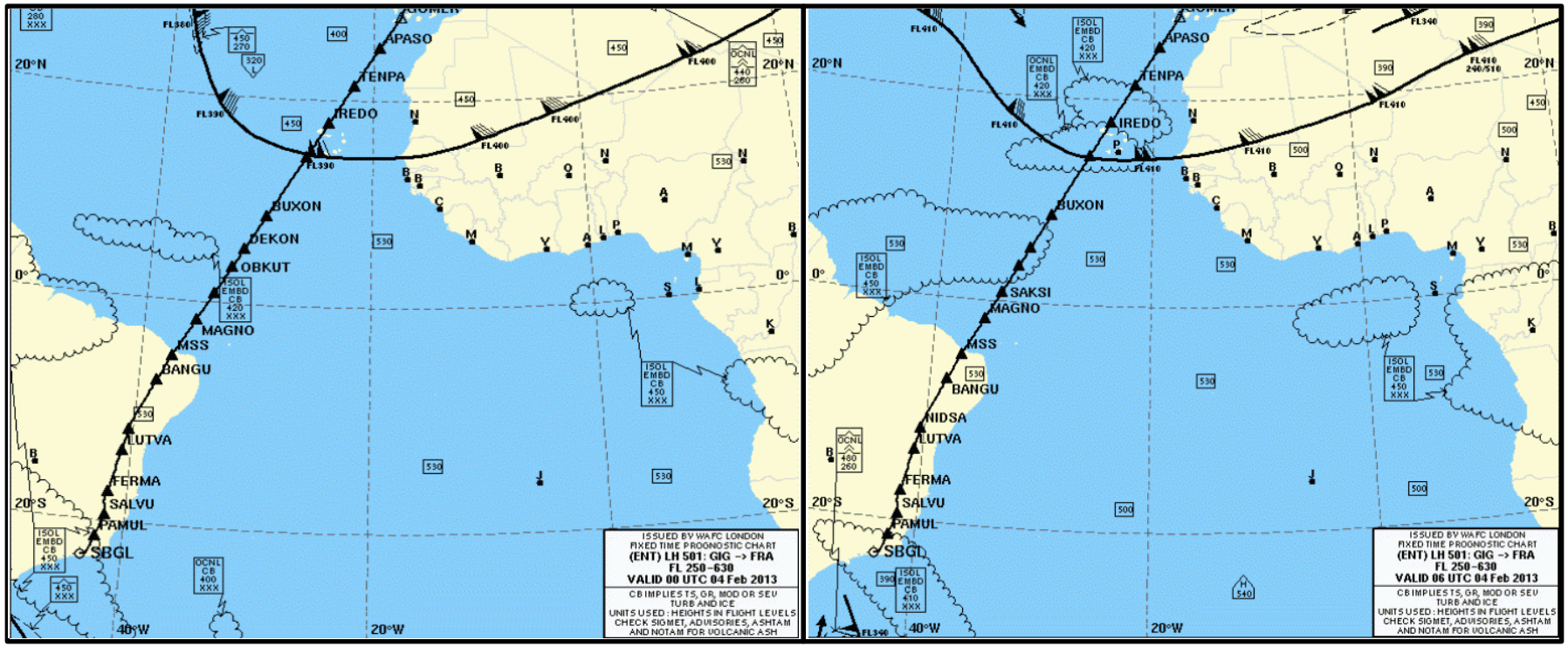
GADCom Lufthansa

Real time link of Rad-TRAM and Cb-TRAM data in 5 EFBs (Electronic Flight Bags) of Lufthansa Cityline aircraft via mobile network on the ground and later in 5 EFBs of Lufthansa aircraft via FlyNet during cruise-flight

DLR

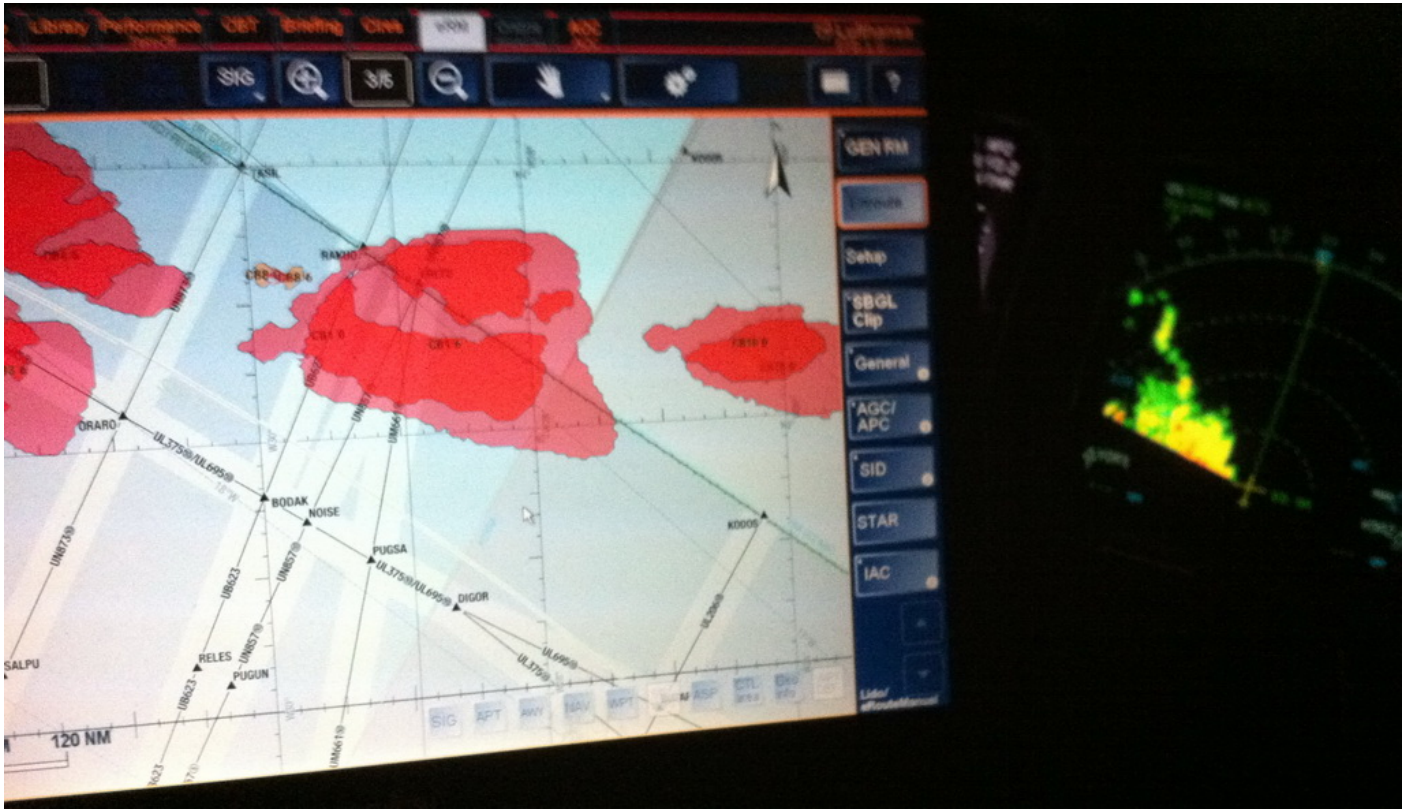
The Test Flight: Rio de Janeiro to Frankfurt, February 2013

According to the charts: Business as usual at the ITCZ



courtesy of A. Ritter, DLH

Then, we uplinked the latest Cb-TRAMs to the eRM …

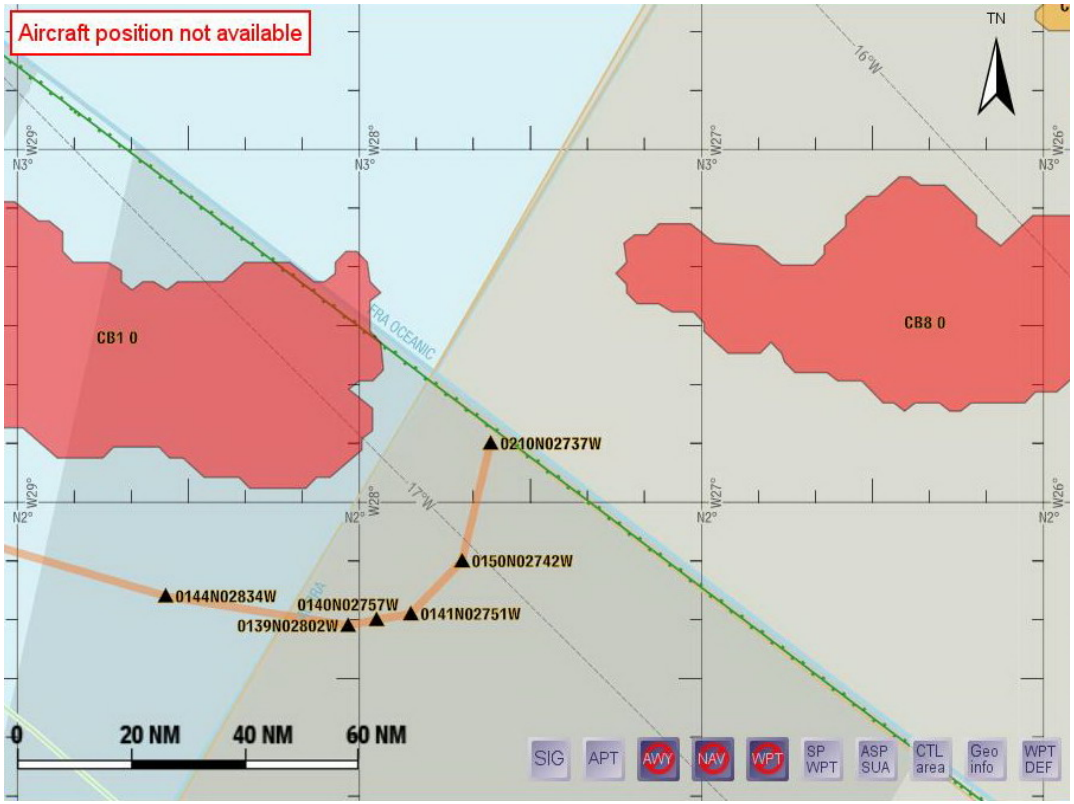


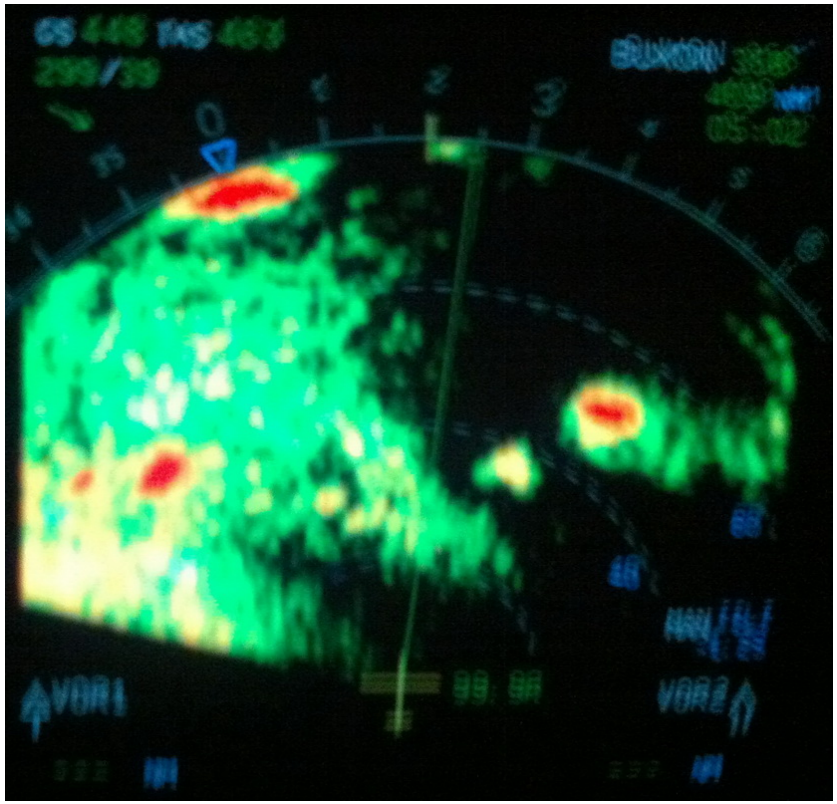
courtesy of A. Ritter, DLH

Then, we uplinked the latest Cb-TRAMs to the eRM …

... planned the safest route with the eRM ...

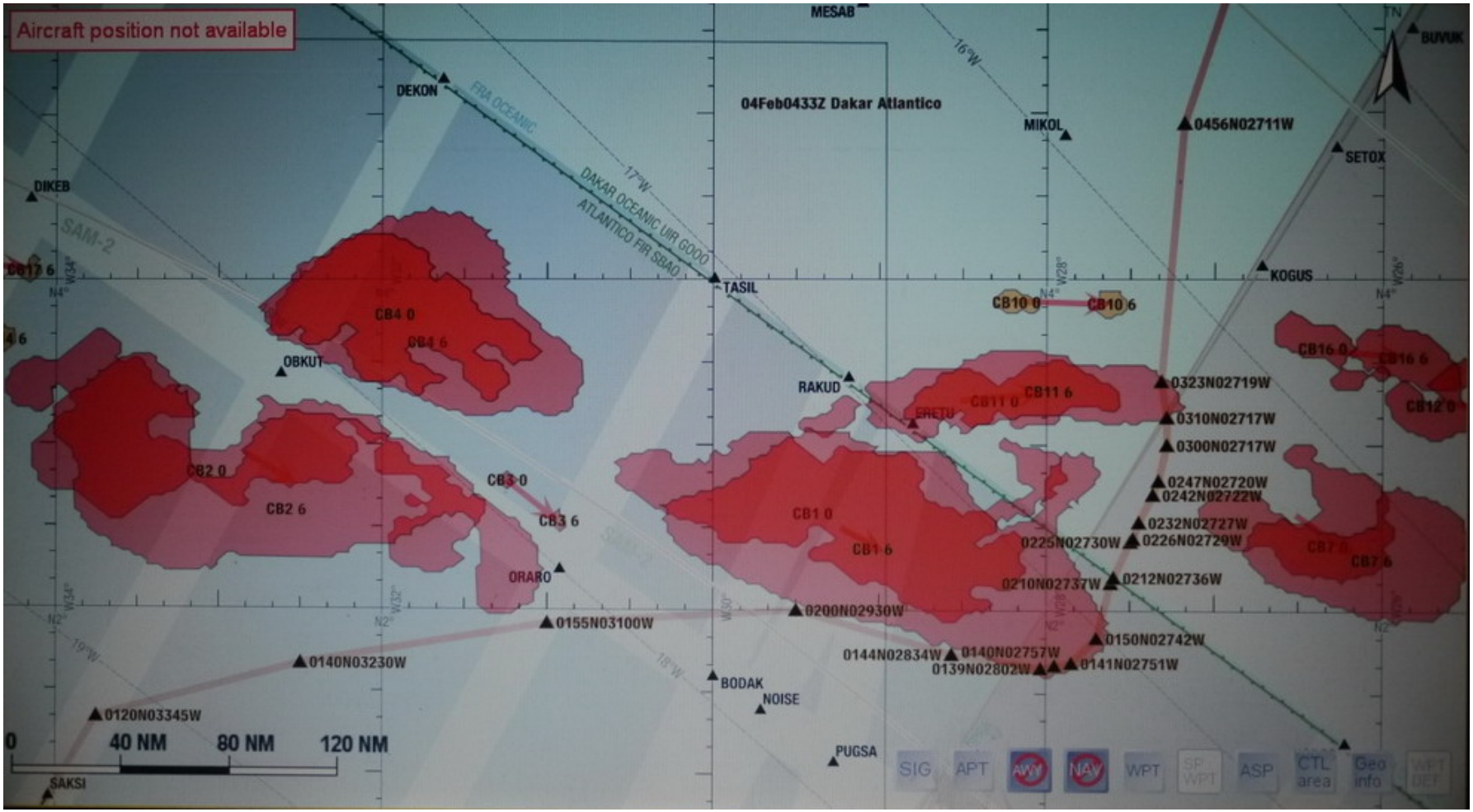
... and flew it tactically by looking at the weather radar





courtesy of A. Ritter, DLH

The result

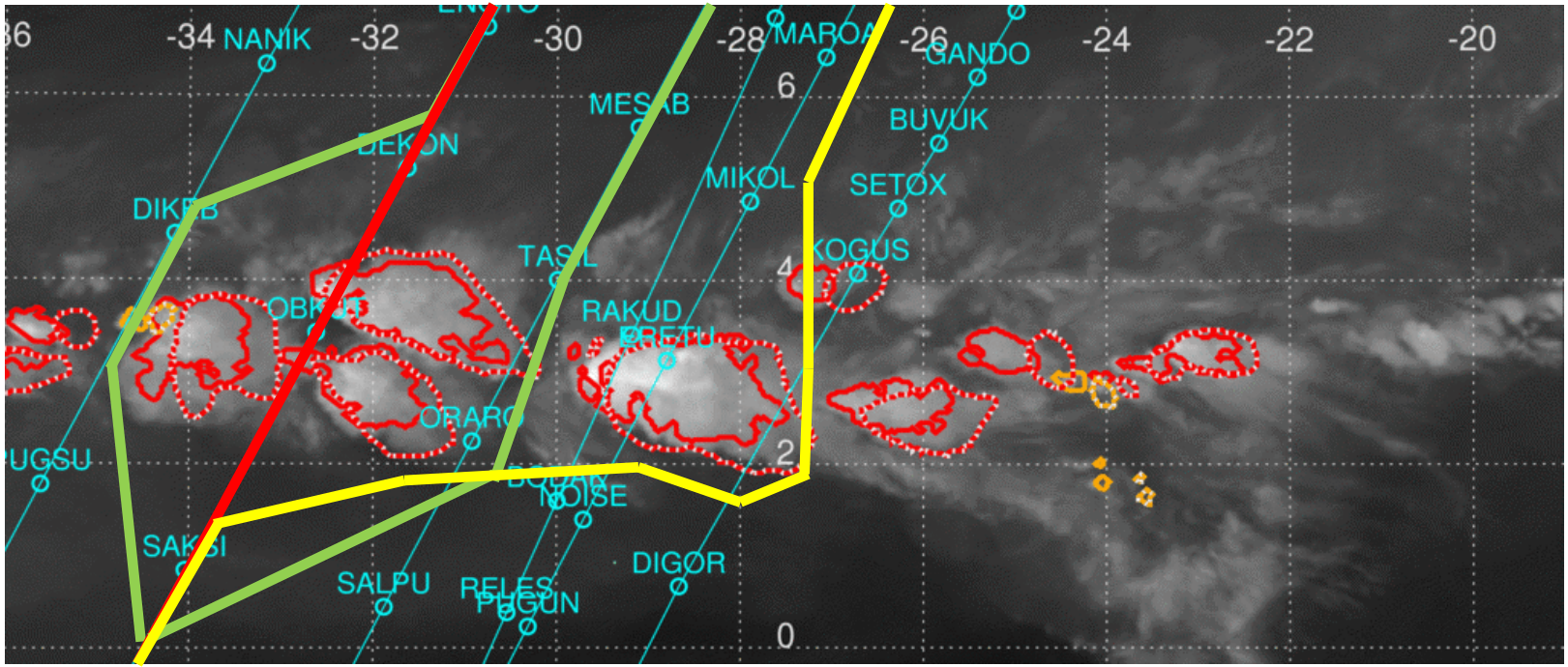


courtesy of A. Ritter, DLH

If we would have uplinked the Cb-TRAM a few minutes earlier ….

… we would have seen the gap on the PUGSU DIKEB route

… or the gap on the ORARO-TASIL route



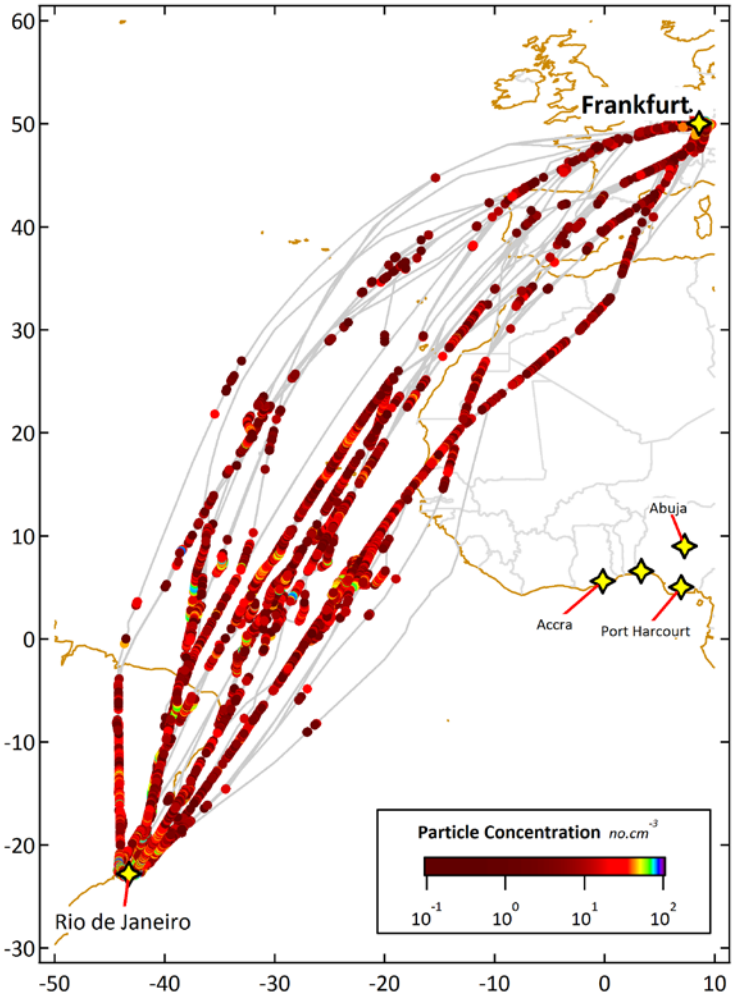
… and could have avoided a 300 NM deviation

courtesy of A. Ritter, DLH

The Test Flight: Rio de Janeiro to Frankfurt, February 2013

GEDCom Lufthansa DLR JÜLICH FORSCHUNGSZENTRUM MANCHESTER 1824 IAGOS

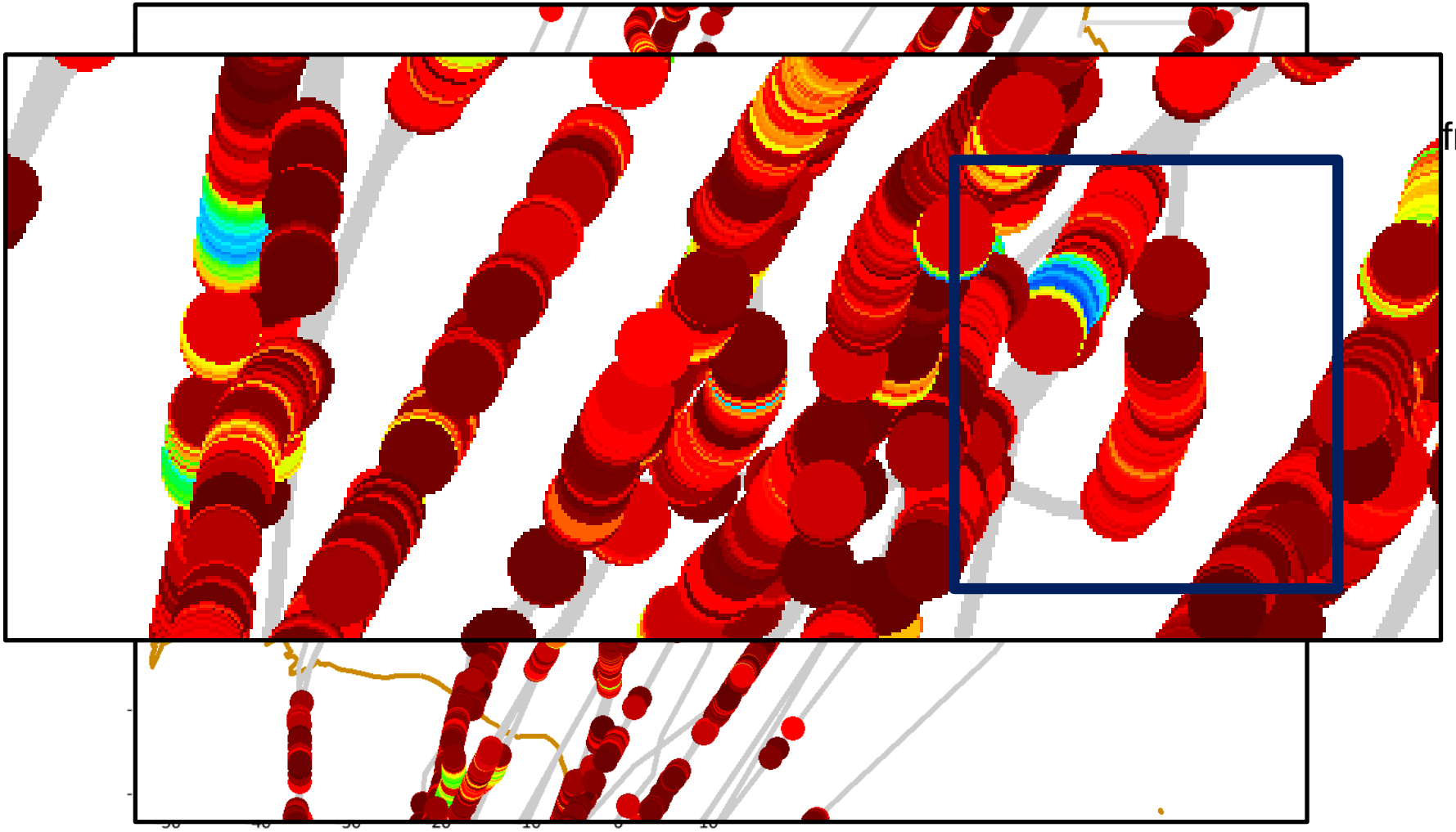
The Result as seen from IAGOS Aircraft



Regular occurrence of high ice crystal number concentrations on flights to or from Rio de Janeiro

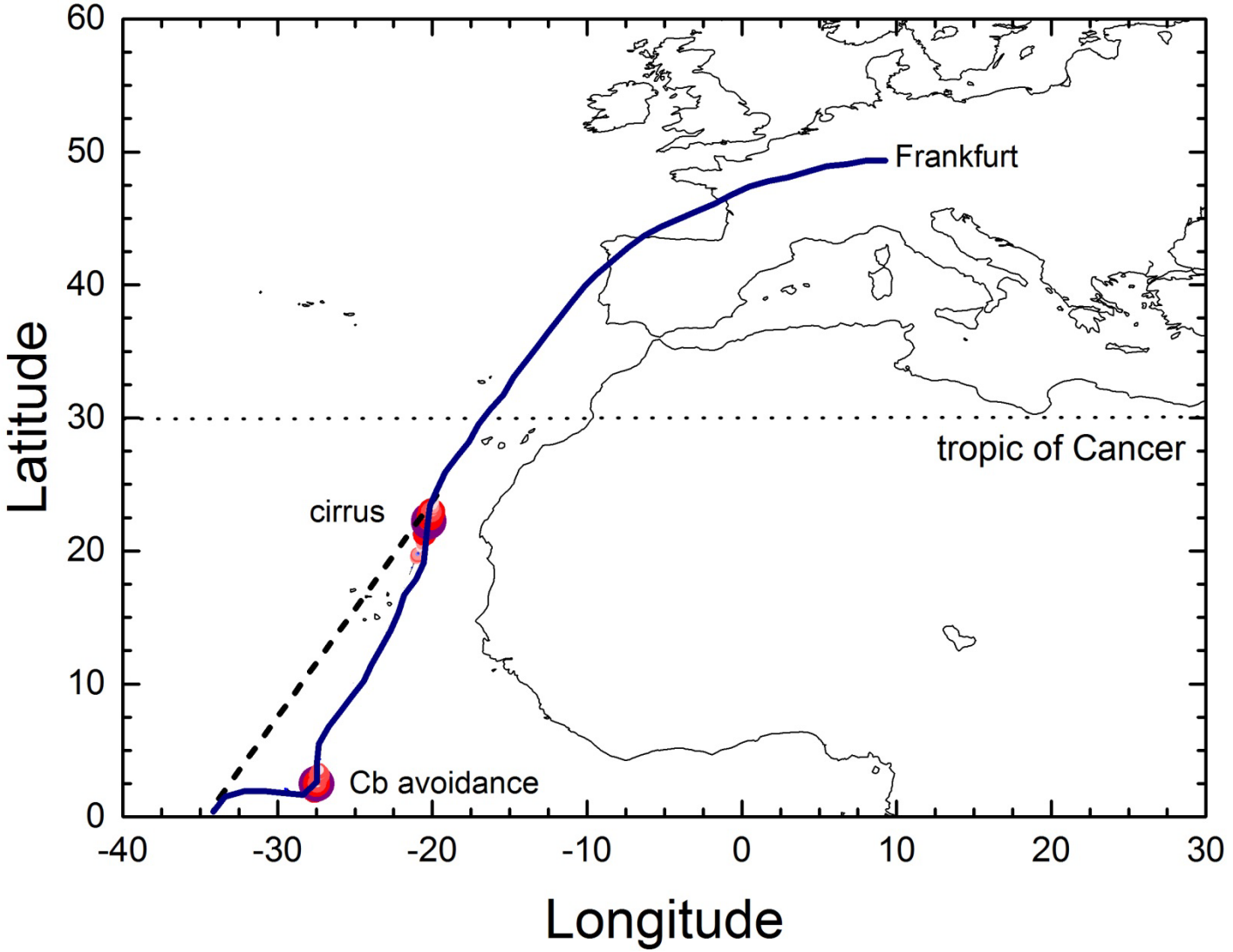
Data from Backscatter Cloud Probe

The Result as seen from IAGOS Aircraft

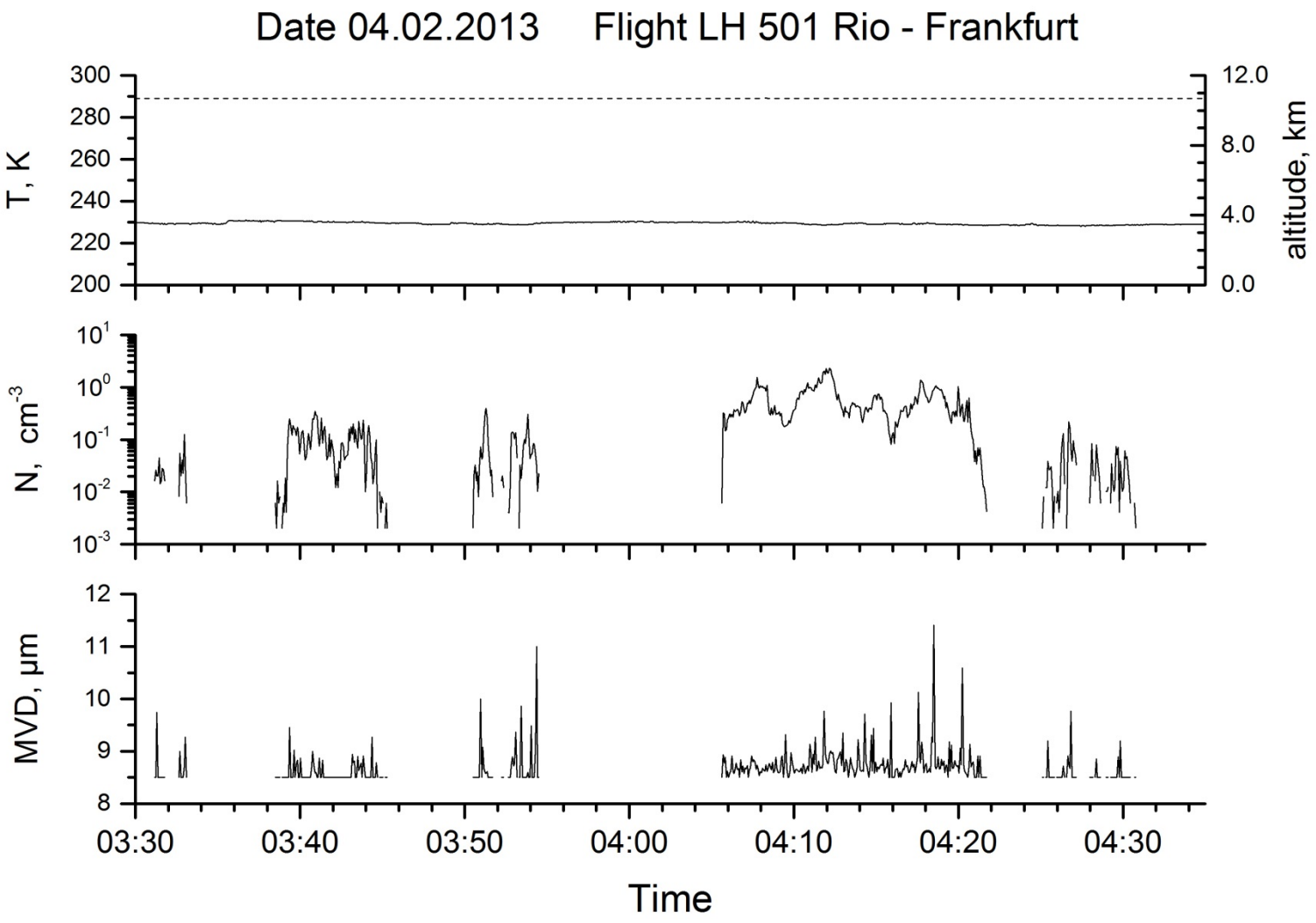


from

The Result as seen from IAGOS Aircraft

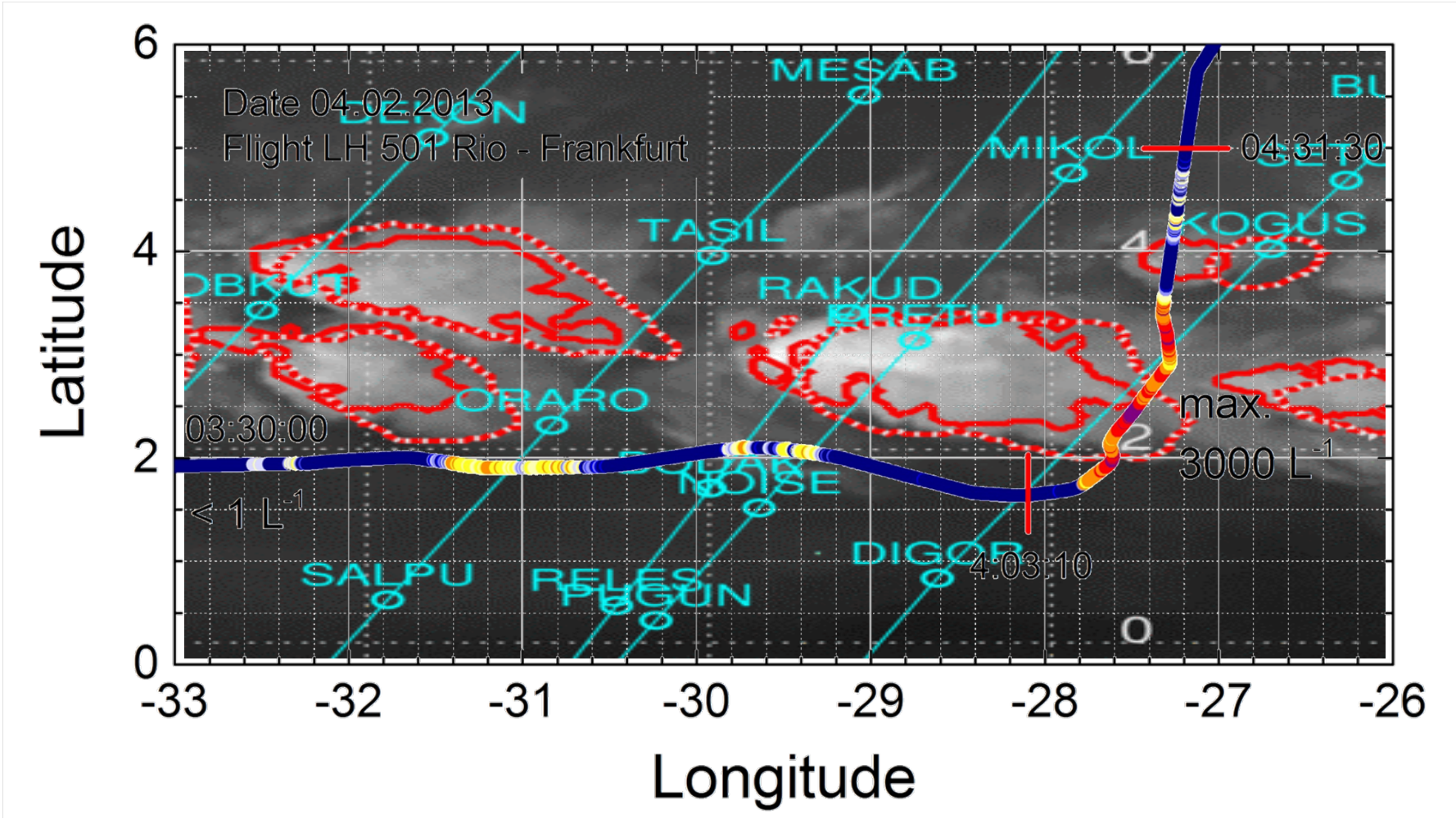


The Result as seen from IAGOS Aircraft

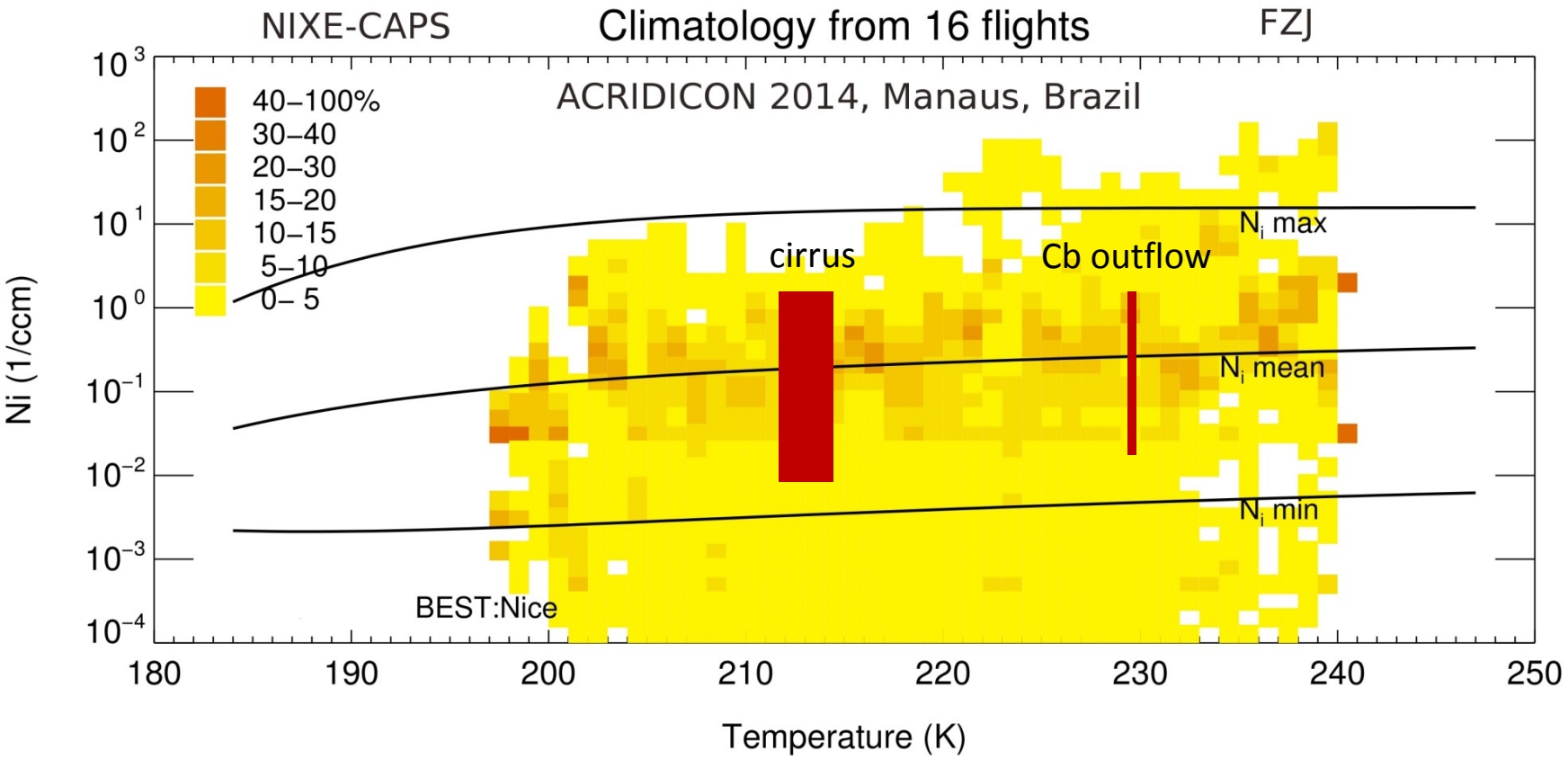


GEDCom Lufthansa DLR JÜLICH FORSCHUNGSZENTRUM MANCHESTER 1824 IAGOS

The Result as seen from IAGOS Aircraft



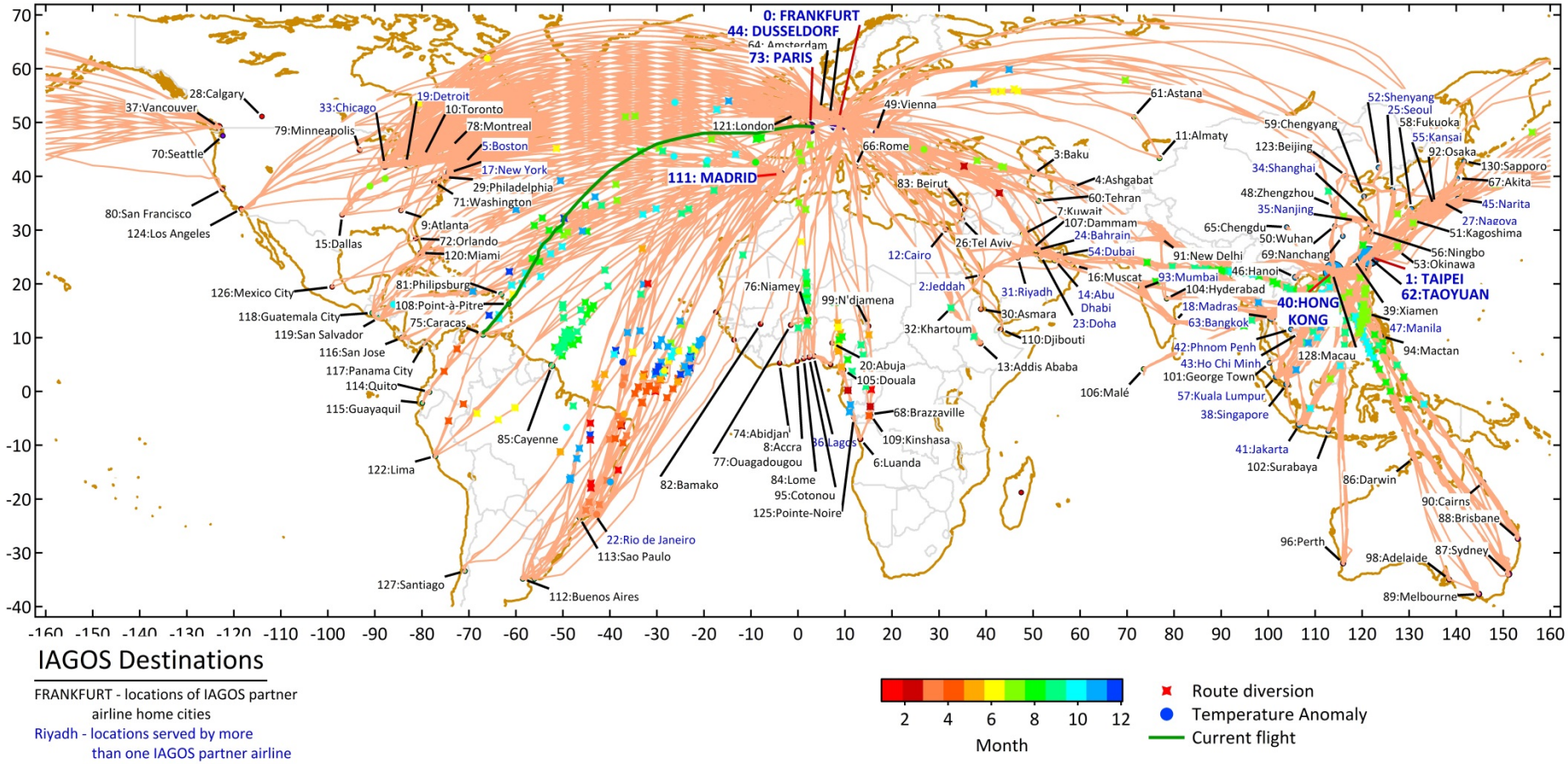
The Result as seen from IAGOS Aircraft



preliminary data from 33h in the outflow of convective systems over Amazonia

M. Krämer and co-workers, Sept. 2014

The Result as seen from IAGOS Aircraft



GEDCom Lufthansa DLR JÜLICH FORSCHUNGSZENTRUM MANCHESTER 1824 IAGOS

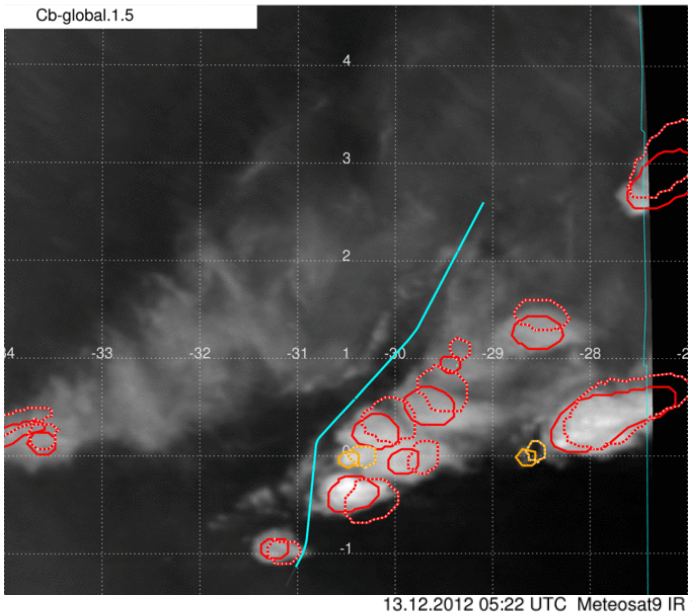
The Result as seen from IAGOS Aircraft

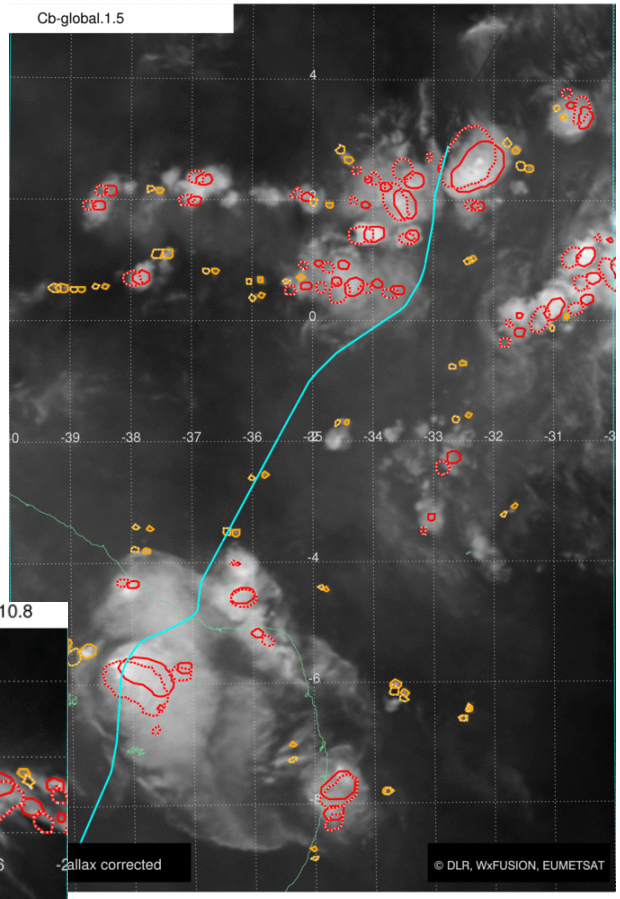
Original File Name (*.tx		Flight Information									Cloud Presence			Archived	Added t	Info for bulk processing				Day	Data point		Location information			
		Start Date	Start Time	End Date	End Time	Flight Hours	Cum'tve Hours	Origin	Destinati	Notes	Take-off	Mid-flight	Land	to CNRS Server?	Sumulative Figures?	QA/QC	Airline	BCP	Base Unit	of week	Start	End	Route diversion ongitud	Route diversion Latitude	T deviation ongitud	T deviation Latitude
BCP20141026231514O7	v3	26-Oct-14	23:15:58	27-Oct-14	11:19:58	12:04:00	187.61	Madrid	Montevideo	R: diversion central Atlantic with v. low N	0	0	0		Y	6	5	6	7	7	5002	6493	-39.09	6.9034		
BCP20141027062502O8	v3	27-Oct-14	06:25:54	27-Oct-14	10:44:58	4:19:04	1803.92	Kuala Lumpı	Taipei	C: event northern S China Sea. R: deviation. TAS: deviation	4	4	0		Y	4	2	8	8	1	1973	2556	110.26	17.224		
BCP20141027062502O8a2																							113.07	19.355		
BCP20141027174005O7	v3	27-Oct-14	17:40:49	28-Oct-14	05:17:21	11:36:32	199.22	Montevideo	Madrid	C: ice event central Atlantic. T: minor deviation. TAS: deviation	0	6	0		Y	6	5	6	7	1	5060	5962	-26.93	6.4361		
BCP20141028112502O5	v3	28-Oct-14	11:25:34	28-Oct-14	20:28:10	9:02:36	6128.42	Sydney	Hong Kong	C: v low N event Sulu Sea. R deviation	0	0	2		Y	2	4	5	5	2	6063	6792	120.87	9.2187		
BCP20141029014927O8	v3	29-Oct-14	01:52:59	29-Oct-14	05:03:23	3:10:24	1834.60	Bangkok	Taipei	C: ice event S China Sea. R: deviation	0	2	0		Y	4	2	8	8	3	1187	1482	111.44	18.051		
BCP20141030092651O5	v3	30-Oct-14	09:27:19	30-Oct-14	17:52:03	8:24:44	6142.74	Hong Kong	Dubai	C: v low N event Arabian Sea. Noisy T, R: deviations	0	6	0		Y	2	4	5	5	4	5397	6107	68.878	21.071		
BCP20141030101523O2	v3	30-Oct-14	10:16:43	30-Oct-14	19:02:19	8:45:36	1843.36	Paris	Philipsburg	No BCP. R: multiple diversions					N	0	3	0	2	4	6135	6311	-52.61	25.594		
BCP20141030101523O2b																					6753	7168	-57.97	22.031		
BCP20141030101523O2c																					7341	7566	-60.9	19.761		
BCP20141031020707O8	v3	31-Oct-14	02:10:07	31-Oct-14	05:21:11	3:11:04	1837.79	Bangkok	Taipei	C: ice event Vietnam coast. R: deviation	0	2	0		Y	4	2	8	8	5	736	1033	107.09	16.077		
BCP20141031101537O2	v3	31-Oct-14	10:17:05	31-Oct-14	18:47:33	8:30:28	1846.30	Paris	Philipsburg	No BCP. R: diversion					N	0	3	0	2	5	5796	5699	-50.15	26.933		
BCP20141101155607O8	v3	01-Nov-14	15:57:11	02-Nov-14	04:57:47	13:00:36	1893.49	Taipei	Vienna	C: event Poland/Belarus; extensive event South Korea/Sea of Japan/SE Russia. R: poss diversion Russian Plain; went the long way	4	4	0		Y	4	2	8	8	6	8951	9648	44.919	59.845		
BCP20141101175503O7a	v3	01-Nov-14	17:55:43	02-Nov-14	05:27:47	11:32:04	248.65	Montevideo	Madrid	C: v low N event central Atlantic. R: deviation	0	0	0		Y	6	5	6	7	6	5279	6465	-23.39	3.5086		
BCP20141101175503O7a2																							-20.9	9.051		
BCP20141030003480O7	v3	03-Nov-14	00:04:28	03-Nov-14	09:46:24	9:41:56	267.95	Panama Cit	Madrid	R: more NW than normal. R: multiple deviation. D: no BCP action	0	0	0		Y	6	5	6	7	1	1409	1865	-69.17	18.592		
BCP20141030003480O7b																					3204	3772	-59.97	33.826		
BCP20141030003480O7c																					4241	4700	-50.5	39.166		
BCP20141030019180O8	v3	03-Nov-14	00:21:14	03-Nov-14	04:26:06	4:04:52	1909.08	Taipei	Kuala Lumpu	C: extensive mid-South China Sea. R: deviation	4	4	4		Y	4	2	8	8	1	1828	2308	111.17	11.937		
BCP20141105172219O7a	v3	05-Nov-14	17:23:03	06-Nov-14	05:04:51	11:41:48	313.94	Buenos Aire	Madrid	R: deviations	0	0	0		Y	6	5	6	7	3	2274	2526	-48.55	-16.43		
BCP20141105172219O7a2																							-48.34	-16.06		
BCP20141105172219O7b1																					2695	3053	-47.03	-12.47		
BCP20141105172219O7b2																							-46.49	-10.57		
BCP20141105172219O7c																					5675	6069	-33.58	11.26		
BCP20141106004255O8	v3	06-Nov-14	00:44:43	06-Nov-14	04:43:59	3:59:16	1945.23	Taipei	Kuala Lumpu	C: extensive southern S China Sea. TAS noisy. R: deviations	4	4	4		Y	4	2	8	8	4	2153	2742	108.55	9.0357		
BCP20141106004255O8a2																							108.16	7.0955		
BCP20141106004255O8b																					2948	3108	105.95	4.0104		
BCP20141106191653O8	v3	06-Nov-14	19:17:29	07-Nov-14	08:03:53	12:46:24	1965.55	Bangkok	Amsterdam	C: Burma, with R deviation, Romania/Slovakia	0	4	4		Y	4	2	8	8	4	423	711	97.925	16.545		
BCP20141107230836O7	v3	07-Nov-14	23:09:16	08-Nov-14	11:28:16	12:19:00	348.20	Madrid	Montevideo	C: event central Atlantic. T: minor T deviation. TAS deviation. R:	0	2	0		Y	6	5	6	7	5	4095	5173	-20.93	9.3918		
BCP20141107230836O7a2																							-23.09	6.1937		
BCP20141107230836O7a3																									-20.41	9.7344
BCP20141107230836O7a4																									-21.17	8.5539
BCP20141108174800O7	v3	08-Nov-14	17:48:32	09-Nov-14	05:29:33	11:40:01	359.87	Montevideo	Madrid	D: BCP reset. R: deviation	0	0	2		Y	6	5	6	7	6	5119	5935	-29.05	9.6625		
BCP20141109225837O7	v3	09-Nov-14	22:59:21	10-Nov-14	08:34:33	9:35:12	379.44	Rio de Jane	Madrid	C: event central Atlantic. T noisy. TAS deviation. R: deviation	2	6	0		Y	6	5	6	7	7	3718	4018	-29.72	8.5063		

Currently have 415 events, but only a fraction of the data have been checked

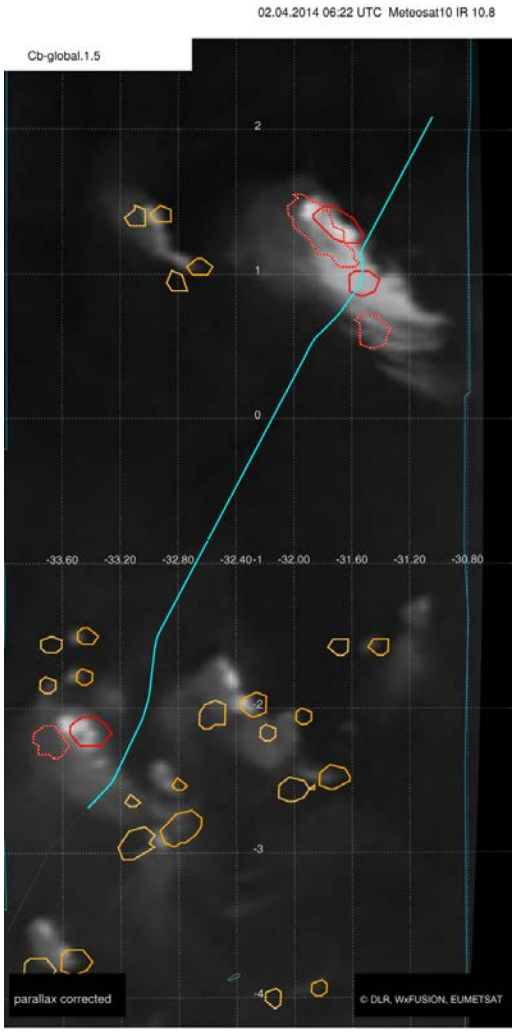
GEDCom Lufthansa DLR JÜLICH FORSCHUNGSZENTRUM MANCHESTER 1824 IAGOS

Further IAGOS avoidance events in Cb-TRAM





EXPERIMENTAL PRODUCT - NOT FOR OPERATIONAL USE



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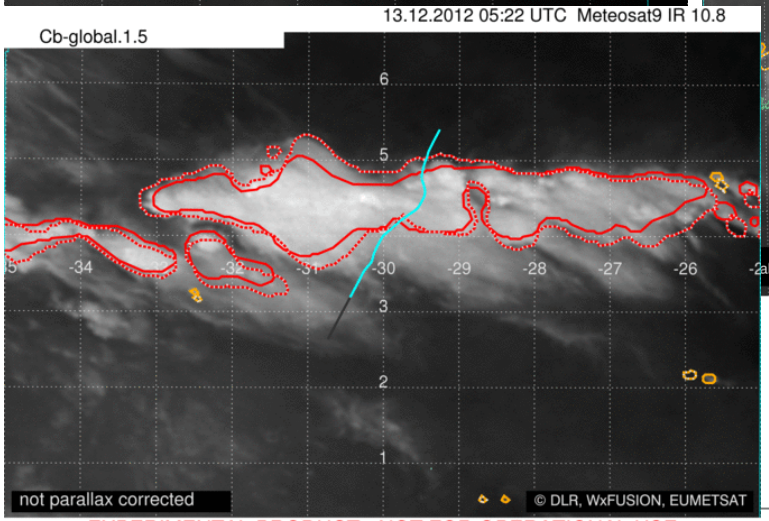
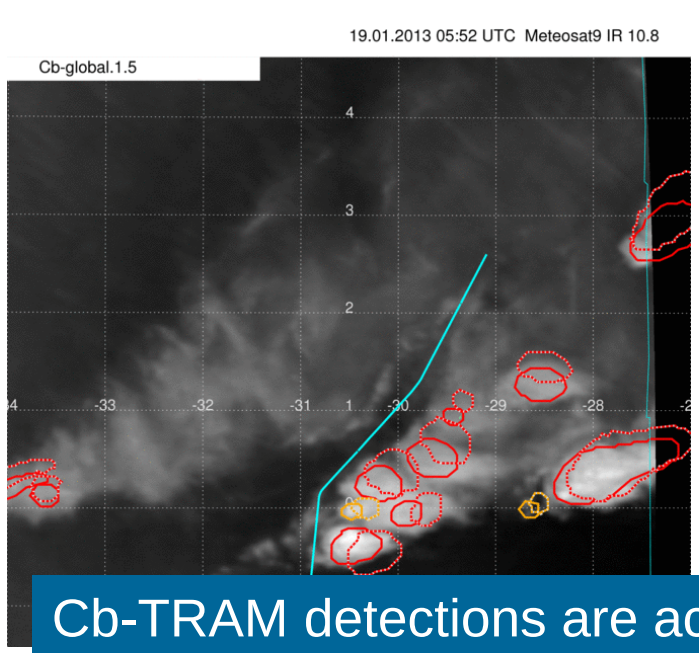
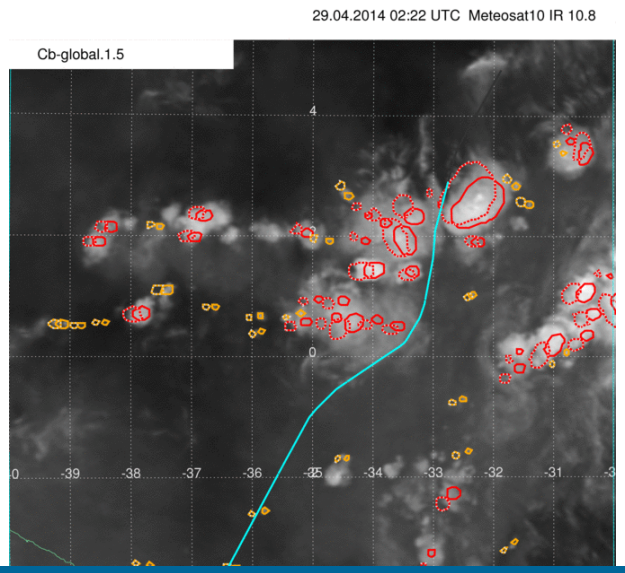


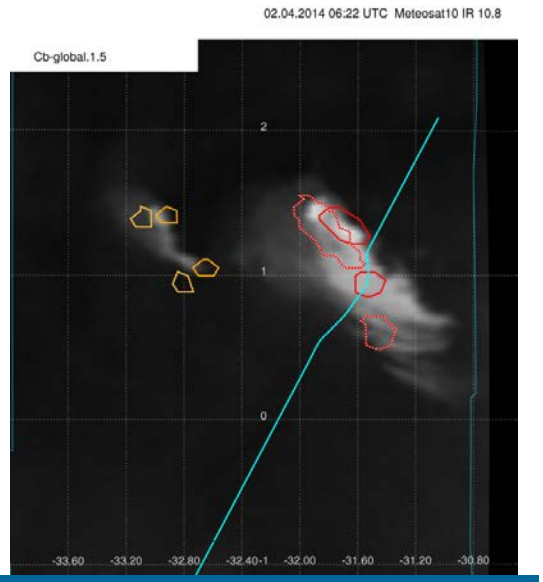
EXPERIMENTAL PRODUCT - NOT FOR OPERATIONAL USE

GEDCom Lufthansa DLR JÜLICH FORSCHUNGSZENTRUM MANCHESTER 1824 IAGOS

Further IAGOS avoidance events in Cb-TRAM







Cb-TRAM detections are accurate, because:

- The avoidance actions by pilots generally follow the contours
  → No conflicts between on-board radar returns and Cb-TRAM detections
- Avoidance routes are safe: they basically show low ice crystal number concentrations. If not, in most cases Cb-TRAM detections are encountered.
  → Additional increase in safety by the use of Cb-TRAM

Conclusion: Cb-TRAM is qualified for strategic flight route planning!

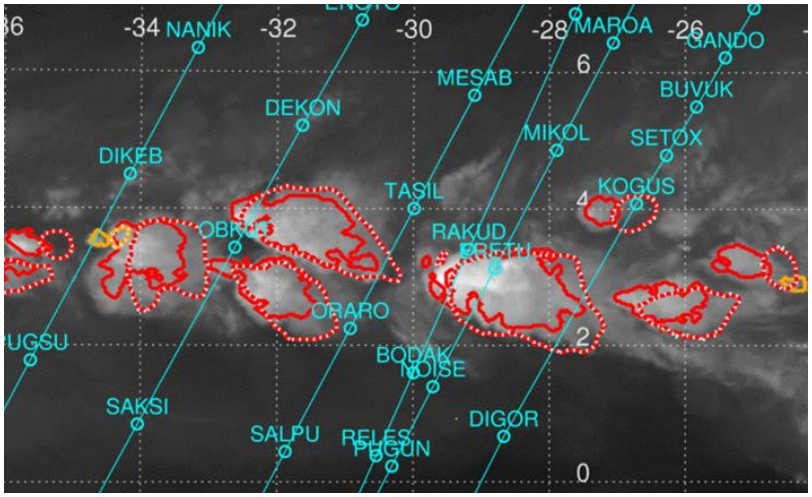
Next Steps

DLR	runs Cb-TRAM for more identified avoidance maneuvers in the MSG Field of View;
Manchester	analyses BCP data for avoidance maneuvers;
FZ Jülich	analyses T, p, RH for avoidance maneuvers; identifies cirrus type encountered during avoidance maneuvers;
All (DLR lead)	combine information from Cb-TRAM & IAGOS cloud type classification and RH for an assessment of Cb-TRAM; publish results.

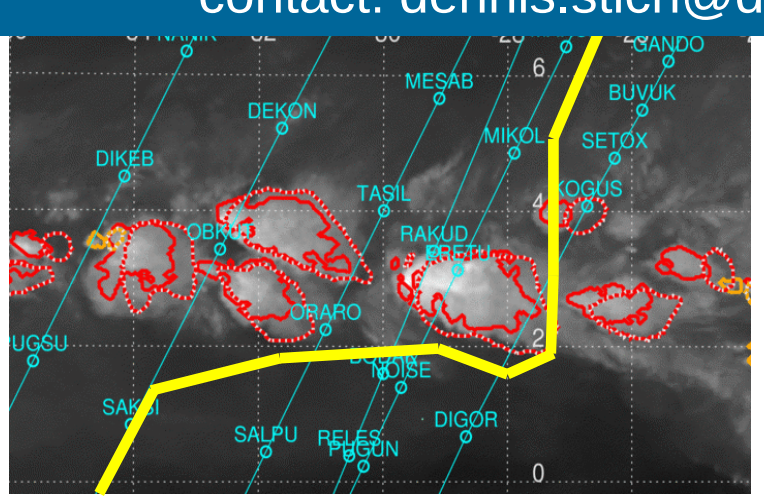
Summary

Thank you for your attention!

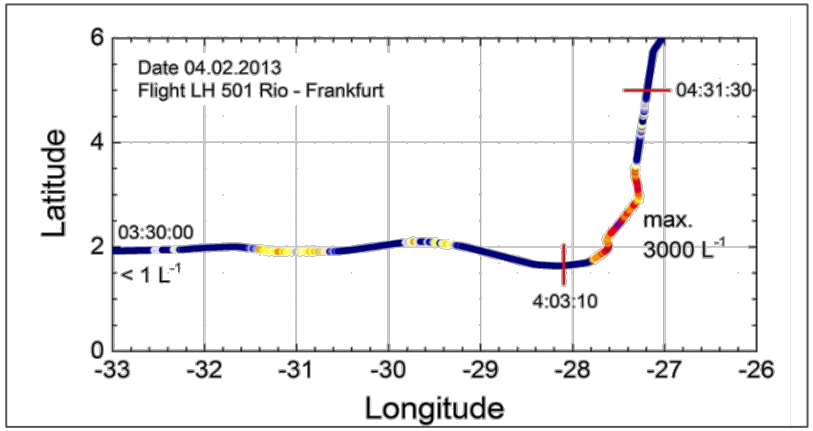
contact: dennis.stich@dlr.de



Severe storms are tracked by satellite data



Aircrew reroutes to avoid storms



On-board detection by IAGOS-BCP verifies cloud-free regions and cloud type during encounters and improves forecast system